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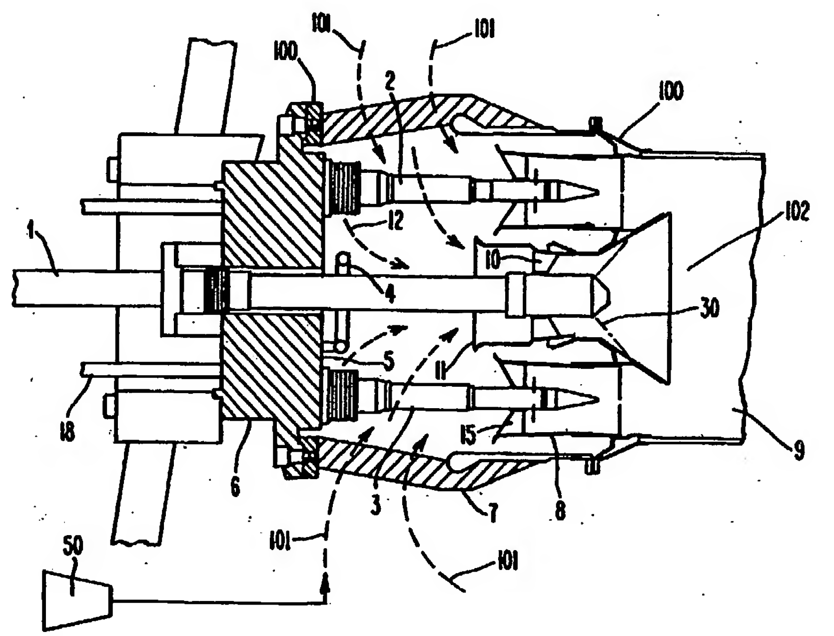

(57) Abstract

Simple and efficient methods and combustor systems for diverting a portion of main fuel to a pilot combustion air stream through a pilot premix nozzle is provided. This increase in premixed air–fuel to the pilot stage and simultaneous reduction in the amount of diffusion fuel flow to the pilot nozzle result in a reduction of nitrogen oxides emission.

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DIFFUSION AND PREMIX PILOT BURNER FOR LOW NOX COMBUSTOR

FIELD OF THE INVENTION

The present invention relates to combustors for turbine engines. More specifically, the present invention relates to methods for reducing the emission of nitrogen oxides by lowering the amount of diffusion fuel supplied to a pilot burn section while increasing the amount of premixed air-fuel mixture to the pilot burn section.

BACKGROUND OF THE INVENTION

Many combustors require a diffusion pilot stage to start the turbine engine and to respond to an increase in the engine load. At full turbine load, the fuel supply to the pilot burner is set at the minimum value required to stabilize the combustion process, which also minimizes nitrogen oxide (NO_x) emissions. The pilot stage is normally a diffusion-type burner, and is therefore a significant contributor of NO_x emissions even though the percentage of fuel supplied to the pilot is quite small (often less than 10%). The pilot flame thus limits the reduction of NO_x emissions that can be obtained with this type of burner.

It is recognized that a substantial reduction in NO_x emission can be achieved by diluted combustion, in a premixing-type combustor in which the combustion takes place after a premixing of fuel and air, as opposed to the diffusion-type combustor mentioned above in which both the mixing of air and fuel and combustion are achieved in a combustion chamber, i.e., a lean fuel mixture reduces the generation of NO_x. One method of premixing of fuel and air is disclosed by U.S. Patent No. 4,671,069, which discloses a technique where air and fuel are premixed and injected through a fuel nozzle. However, premixing requires additional valving and control systems, adding to the

complexity of the fuel nozzle. In fact, all current methods of providing a premixed air-fuel to the pilot burn section require additional fuel passages, including valving, manifolds, piping and/or control system modifications all of which result in complex fuel nozzles.

Thus, there remains a need for a simple and efficient method for supplying premixed air-fuel to the pilot burn section to reduce the amount of diffusion fuel requirement, thereby reducing the emission of NO_x.

SUMMARY OF THE INVENTION

The present invention provides methods and apparatus for reduced NO_x emission in combustors used in gas turbines by decreasing the amount of a diffusion fuel to a pilot section, and then increasing the amount of a premixed fuel to the pilot section. The premixed fuel is obtained by injecting a fuel obtained from a main fuel manifold into a pilot nozzle combustion air stream through a pilot premix nozzle. The present invention is based upon a recognition that a large reduction of NO_x can be achieved in the pilot burn section by decreasing the amount of diffusion fuel and increasing the premixed fuel to provide leaner fuel for combustion. The amount of premixed fuel is proportionally increased as the amount of diffusion fuel is decreased to maintain stable pilot stage combustion flame in the combustion system.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows one preferred embodiment of a combustor constructed in accordance with the present invention;

FIG. 2 shows a detailed illustration of a pilot premix nozzle shown in FIG. 1;

FIG. 3 shows a view of a combustor fuel nozzle against the flow of fuel;

FIG. 4 shows a schematic illustration of another embodiment of the present invention;

FIG. 5 shows a view of FIG. 4 against the flow of fuel; and

FIG. 6 shows another combustor fuel nozzle in accordance with an embodiment of the present invention;

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is generally directed to combustors in a gas turbine engine that require a diffusion fuel pilot stage and operates on the principle of premixing

the main stage fuel and air to minimize NO_x emissions. A typical combustor to which the present invention is applicable has a pilot stage and two or more additional stages that are brought on-line progressively as the load increases. The pilot stage is used to start the engine and increase the load of the turbine engine until full power is reached.

As shown in FIG. 1, the combustor 100 has a nozzle housing 6, with a nozzle housing base 5. A diffusion fuel pilot nozzle 1, main fuel nozzles A 2 and main fuel nozzles B 3 are attached to the nozzle housing base 5. A pilot premix nozzle 4 is also attached to the nozzle housing base 5. The stage B main fuel manifold 13 has fuel inlets 16 which provides fuel to main nozzle B and, in addition, it also has a fuel inlet 17 which provides fuel 32 to the pilot swirler 11 (FIG. 1). Also shown in FIG. 1 is a fuel inlet pipe 18 that provides fuel to the main fuel manifold B. Compressed air 101 from the compressor flows between support ribs 7 to the main fuel swirler 8. At this point, the air mixes with the main fuel and is carried into the main combustion zone 9, where it burns. In order to facilitate the mixing of air and fuel, stationary turning vanes 15 are disposed inside the main fuel swirler 8. Other portions of the compressed air enter through another set of stationary turning vanes 10 located inside a pilot swirler 11. At this point, this portion of the compressed air mixes with pilot fuel 30 and is carried into the pilot burn area 102 where it combusts. A pilot premix nozzle 4 is located in the pilot nozzle combustion air stream 12.

As shown in FIG. 2, the pilot premix nozzle 4 is connected to the stage B main fuel manifold 13. Typically, stage B is not activated until the turbine load reaches about 60%. In general, only stage A and the pilot are activated when the turbine load is less than about 60%. Thus, no fuel flows from stage B main fuel manifold 13 to the pilot premix nozzle 4 until stage B is activated. As explained above. the stage B main fuel manifold 13 is located in the nozzle housing 6. When main fuel nozzle B 3 is activated, the fuel flow is split between the main fuel nozzle B 3 and the pilot premix nozzle 4. As the fuel 31 from the pilot premix nozzle 4 is injected into the pilot nozzle combustion air stream 12 (FIG. 1) where it mixes with the air and due to the pressure gradient flows toward pilot burn section 102. When the premixed fuel is provided to the pilot burn section, flow of diffusion fuel 30 to the pilot nozzle 1 is decreased, and accordingly results in a lowering of the flame temperature, thereby reducing NO_x emissions. The amount of fuel flow split between the main fuel nozzle

B 3 and the pilot premix nozzle 4 is determined by the relative size and number of the injection ports in the two stages. The total fuel flow to the stage B main fuel manifold 13 is increased to compensate for the amount supplying the pilot premix nozzle such that the fuel supplied to the main fuel nozzle B 3 is not affected. As the premixed fuel to the pilot stage is gradually increased with the load through the pilot premix nozzle 4, the fuel flow to the pilot diffusion stage is proportionally reduced. The exact position of the pilot premix nozzle 4 and the percent of the fuel supplied is determined at the design stage as required to optimize performance.

As shown in FIG. 3, pilot nozzle 4 is surrounded by main fuel nozzles, which comprise alternating main fuel nozzle A 2 and main fuel nozzle B 3. Typically, when the turbine load is less than 60% only the main fuel nozzle A 2 is on-line. Thus, no fuel is supplied by main fuel nozzle B 3 and, hence, no premixed fuel is supplied to the pilot stage. Of course, the pilot stage (1, seen in FIG. 1) is active at all times except when the turbine is completely off line.

The ratio of air to fuel mixture provided by the pilot premix nozzle is such that no combustion takes place until it is further mixed with diffusion fuel from the pilot nozzle, *i.e.*, the mixture is too lean to burn without further enrichment of fuel provided by the pilot nozzle. Thus, no flashback of the flame is encountered. Typically, in preferred embodiments, the stationary turning vane 10 is located inside the pilot swirler 11 to provide swirling action of air to facilitate mixing of fuel and air.

In general, during full load operation, the diffusion fuel provided to the pilot nozzle is reduced from approximately 10% to about 4-6% of the total fuel consumption. The premix fuel from pilot premix nozzle contributes an equal amount of fuel, i.e., about 4-6% of the total fuel consumption. Thus, the amount of fuel required in the pilot stage to provide a stable pilot section flame is optimized. The proper ratio of premixed fuel and diffusion fuel can be easily determined depending upon the particular combustor system and operating conditions.

FIGS. 4-5 illustrate, respectively, a side elevation, in cross section, and a front view, looking against flow, of a Stage B premix nozzle made in accordance with the present invention. The cross-section of FIG. 4 is taken along lines B-B of FIG. 5.

As seen in FIGS. 4-5, a passageway 40 is provided that permits fluid flow from Stage B. This passageway 40 is in turn connected to and in fluid communication with a pilot premix supply 42. The pilot premix supply 42 is in turn connected to and in fluid communication with the pilot premix nozzle 44.

Referring now to FIG. 6, it can be seen that when the stage B main fuel manifold 13 is located on the front face of the nozzle housing base 5, the pilot premix nozzle 4 (seen in FIG. 1) can be replaced by a series of openings 103 connected to and in fluid communication with this passage.

Those skilled in the art will appreciate that numerous changes and modifications may be made to the preferred embodiments of the invention and that such changes and modifications may be made without departing from the spirit of the invention. It is therefore intended that the appended claims cover all such equivalent variations as fall within the true spirit and scope of the invention.

CLAIMS:

1. A combustor turbine comprising:

a nozzle housing with a base, a burn section located adjacent to said nozzle housing and disposed on the opposite side of said base;

a main fuel manifold located at said base of said nozzle housing;

a pilot nozzle attached to said base of said nozzle housing, wherein said pilot nozzle is located inside said nozzle housing and said pilot nozzle comprises a diffusion fuel system; a main nozzle attached to said base of said nozzle housing, said main nozzle being located inside said nozzle housing and parallel to longitudinal axis of said pilot nozzle;a system for introducing a premixed air-fuel to said pilot section comprising a pilot nozzle combustion air stream; and a pilot premix nozzle, wherein said pilot premix nozzle is connected to said main fuel manifold, and said pilot premix nozzle is located in the line of said pilot nozzle combustion air stream; and

a means for reducing the amount of fuel supplied to said pilot nozzle in proportion to increase in the amount of the premixed fuel.

2. The combustion system of claim 1 further comprising a pilot swirler, said pilot swirler surrounding a portion of said pilot nozzle and extending beyond the end of said pilot nozzle in the opposite direction of said base of said nozzle housing.

3. The combustion system of claim 2 further comprising a turning vane located inside said pilot swirler.

4. The combustion system of claim 1 further comprising a main fuel swirler, said main fuel combustion basket surrounding a portion of said main nozzle and extending beyond the end of said main nozzle in the opposite direction of said base of said nozzle housing.

5. The manifold swirler of claim 4 further comprising a turning vane located inside said main fuel combustion basket.

6. The combustion system of claim 1 wherein said pilot nozzle air stream is introduced near the base of said nozzle housing and flows towards said pilot burn section.

7. The combustion system of claim 1 wherein the fuel from said pilot premix nozzle is increased proportionally to decrease in fuel from said diffusion fuel system of said pilot nozzle.

8. A method for reducing emission of nitrogen oxides in a combustor comprising:

decreasing the amount of a diffusion fuel to a pilot burner; and

increasing the amount of a premixed fuel to said pilot burner,

wherein said premixed fuel is obtained by injecting a fuel obtained from a main fuel manifold into a pilot nozzle combustion air stream through a pilot premix nozzle.

9. The method of claim 8 wherein said pilot premix nozzle is connected to said main fuel manifold.

10. The method of claim 8 wherein the size of said pilot premix nozzle is selected to provide substantially optimum performance.

11. The method of claim 10 wherein said pilot premix manifold is positioned in said pilot nozzle combustion air stream to provide optimum performance.

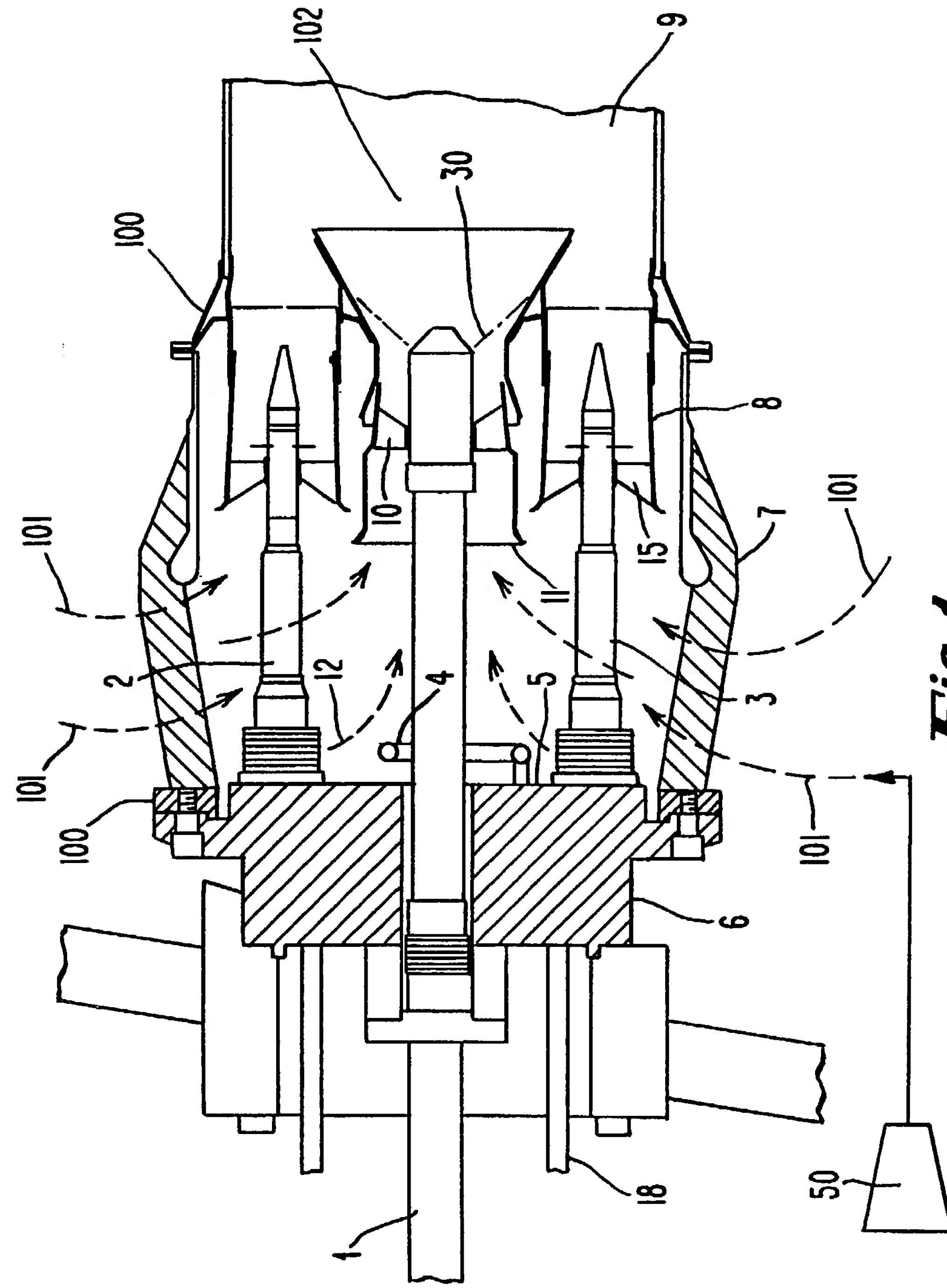

Fig.1

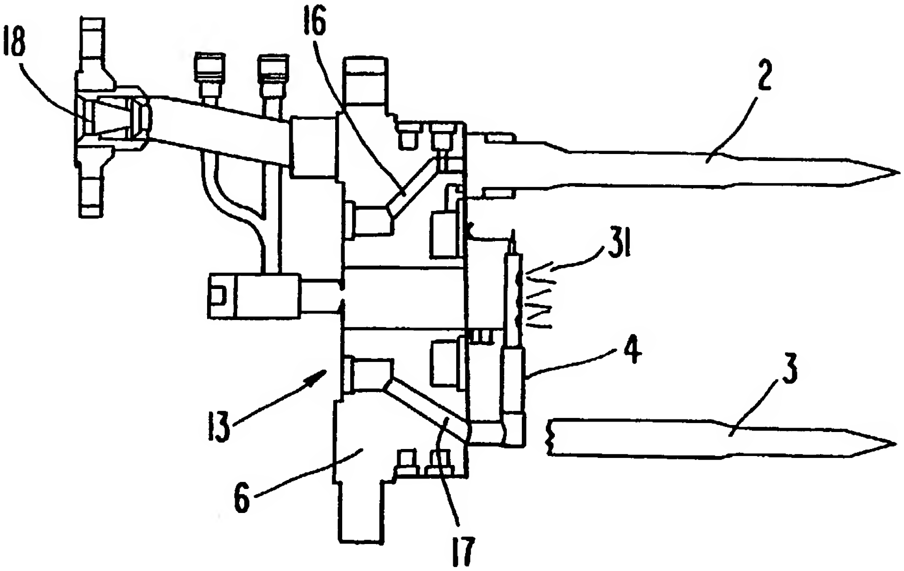

Fig. 2

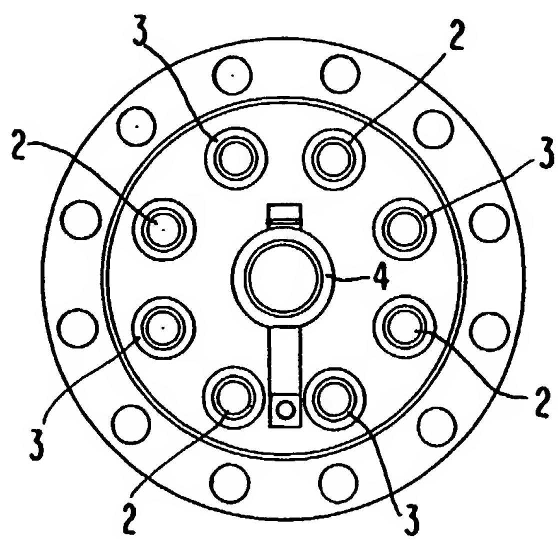

Fig. 3

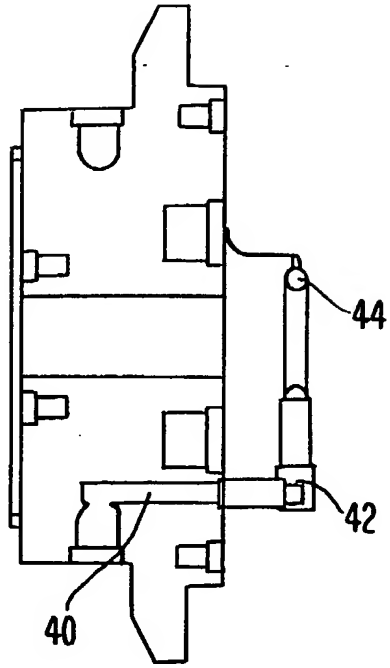

Fig. 4

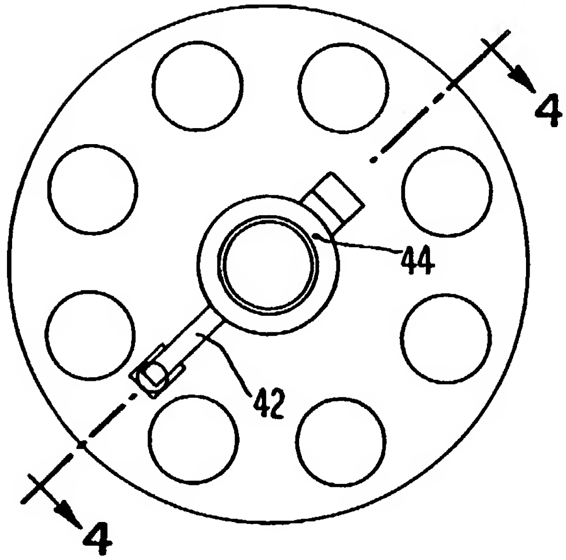

Fig. 5

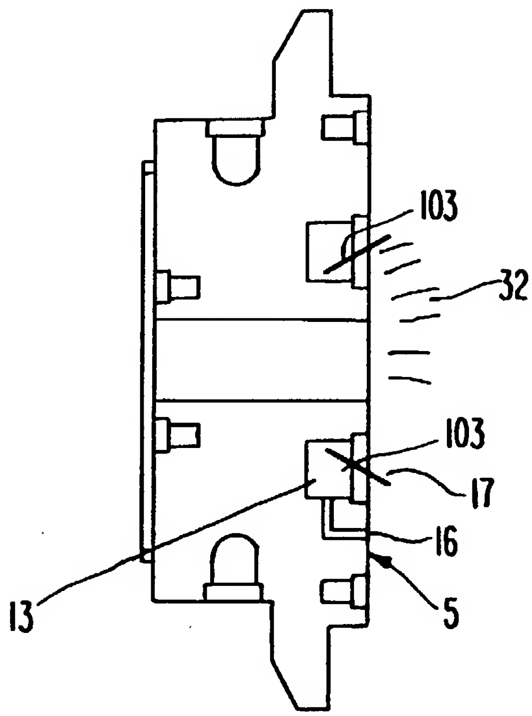

Fig. 6

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/US 97/22401

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F23R3/34 F23R3/28

According to International Patent Classification(IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F23R

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	EP 0 766 045 A (WESTINGHOUSE ELECTRIC CORP) 2 April 1997	1-7
Y	see column 4, line 29 - column 5, line 8 see column 6, line 44 - line 56; figures 4,7 ---	8,9
Y	US 4 589 260 A (KROCKOW WOLFRAM) 20 May 1986 see column 4, line 36 - column 5, line 18 see column 5, line 63 - column 7, line 42; figures ---	8,9
X	EP 0 488 556 A (GEN ELECTRIC) 3 June 1992 see abstract see column 4, line 45 - column 6, line 53; figures 2-5 ---	1-6
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[X] Further documents are listed in the continuation of box C.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 594 127 A (MITSUBISHI HEAVY IND LTD) 27 April 1994 see abstract; figures	1
A	US 5 259 184 A (BORKOWICZ RICHARD ET AL) 9 November 1993 see column 2, line 20 - line 35 see column 3, line 33 - column 4, line 9 see figures	1
A	US 5 415 000 A (MUMFORD STEPHEN E ET AL) 16 May 1995 see column 4, line 24 - line 41	1,8

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